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APPARATUS AND METHOD FOR TREATING SUBSTRATES

Background of the Invention

The present invention relates to an apparatus and to a method for treating substrates in a tank that can be filled with at least two treatment fluids.

Such apparatus are designated as Single Tank Tool (STT) since within a treatment tank a number of substrate treatments can be effected by introducing different treatment fluids. Such an apparatus is described, for example, in the not pre-published German patent application belonging to the same applicant and having the number 197 38 147, as well as in DE-A-196 16 402 of the same applicant. With such apparatus, respectively different apparatus are associated with one treatment tank. These apparatus include, among others, a wafer introduction/delivery station, a device for concentrating the wafers, which devices are designated pushers, a transport mechanism, an electronic switching or control device, as well as at least two treatment fluid supply units. These aforementioned apparatus respectively have a capacity that is designed for a single tank.

At least one of the treatment fluid supply units contains as a rule a treatment fluid processing unit in which a treatment fluid, for example SC1 comprising a mixture of ammonia, hydrogen peroxide, and water,

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is mixed and heated. The treatment fluid processing unit, as well as the preparation and processing themselves, result in a considerable cost factor during the treatment of substrates.

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JP-A-61-133633 discloses an apparatus for the treatment of semiconductor wafers using three identical treatment tanks that are supplied with treatment fluid via a common supply unit. The treatment tanks are sequentially used for the treatment of the wafers in such a way that at any point in time only a single tank is used for the treatment of wafers. The remaining tanks are held in readiness in order after conclusion of a specific number of treatment cycles in the already used tank to be used as the treatment tank. This apparatus requires space for three treatment tanks, although at any given point in time only one of the tanks is used for the treatment of wafers. This high requirement for space leads to high costs for the apparatus, which are generally operated in expensive clean streams.

JP-A-6-314683 discloses an apparatus for the treatment of semiconductor wafers and has a plurality of treatment tanks, which are supplied with treatment fluid over a common supply unit. With this apparatus, a plurality of treatment tanks can be used simultaneously, whereby a treatment tank that at any given time is not being used is

kept in readiness in order to ensure a continuous treatment. In this connection, the supply unit is designed for the simultaneous supply of all of the tanks, although these tanks are not all in use at any given point in time. By constantly keeping a tank in readiness, as well as having a supply unit that is designed for all of the treatment tanks, there again results a high requirement for space.

JP-A-6-204201 also discloses an apparatus for the treatment of semiconductor wafers using a plurality of treatment tanks that are supplied with treatment fluid by a common supply unit. The tanks are all used at the same time and the supply unit is designed for the simultaneous supply of all tanks.

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Proceeding from the aforementioned apparatus, it is an object of the present invention to provide an apparatus and a method for treating substrates, which make possible an economical treatment of the substrates. Furthermore, the throughput of the apparatus is to be increased without a significant increased requirement for space for the apparatus, since these apparatus are generally operated in clean streams that are very cost intensive with regard to their preparation and operation.

Summary of the Invention

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The object of the present invention is inventively realized by a method for treating substrates in at least one of two tanks, each of which can be filled with at least two treatment fluids, by providing the following method steps: a) Preparing a first treatment fluid in a treatment fluid processing unit that is common to, or shared by, both of the tanks, with the capacity of the processing unit being designed for one treatment tank, b) Charging the tank with substrates, c) Introducing the first treatment fluid into the tank for a predetermined period of time, d) Introducing the at least second treatment fluid into the tank and e) Removing the substrates from the tank, whereby the method sequence or steps are controlled in parallel, and in a time staggered manner, in the respective tanks in such a way that a period of time sufficient for the preparation of the first treatment fluid is provided between the end of the step c) in one of the tanks and the start of the step c) in the other tank. By using two treatment tanks, and due to the time staggered control of the method steps in the tanks, it is possible to double the throughput capacity of a conventional single tank processor, i.e. Single Tank Tool. Due to the time staggered control of the method steps in the respective tanks, it is possible to jointly use the apparatus and elements that are connected with the tanks without the capacity thereof having to be designed for a plurality of tanks. As a result, no two complete Single Tank Tools are required, so that the floor space can

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be significantly reduced relative to the use of two conventional Single Tank Tools. This is particularly advantageous with regard to the fact that the apparatus are generally disposed in clean streams, the production and maintenance of which is very cost intensive.

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The first treatment fluid is preferably withdrawn prior to the introduction of the second treatment, or is displaced out of the tank by the introduction of the second treatment fluid.

During preparation from different chemicals, the first treatment fluid is preferably mixed and/or heated in order to be able to provide, for the treatment, freshly prepared treatment fluid having the respectively required mixture ratios. Pursuant to one preferred specific embodiment, after the end of the step c) the first treatment fluid is respectively at least partially returned to the treatment fluid processing unit in order to reprocess the treatment fluid, which leads to considerable savings in cost for the chemicals used since these chemicals are at least partially reused.

During the treatment a third treatment fluid is preferably introduced into the tank, whereby either the second or the third fluid is a rinsing fluid for the cleaning of the substrates.

For a further saving in space the second and/or third treatment fluids are made available by means of treatment fluid supply units that are respectively common to both tanks, and the tanks are charged and unloaded by means of a common handling mechanism. Pursuant to one specific embodiment of the present invention, for charging and unloading one of the tanks the substrates are moved over the other tank, whereby this movement is effected only during a rinsing process in the other tank in order to prevent adversely affecting the substrates due to a chemical treatment in the other tank. Pursuant to an alternative specific embodiment of the present invention, a closure device is provided for closing off the treatment tank during a movement of the handling mechanism thereover. The closure mechanism is preferably an essentially flat lid. The handling mechanism preferably accesses a common introduction/delivery station.

For a good and rapid drying of the substrates, the substrates are dried during removal from the respective tank pursuant to the Marangoni principle, whereby, however, alternative drying processes could also be utilized.

The object of the present invention is also realized by an apparatus for treating substrates, which apparatus includes two tanks that can be

filled with at least two treatment fluids, at least one first treatment fluid supply unit that is common to, or shared by, the tanks and has at least one treatment fluid processing unit, the capacity of which is designed for one tank, at least one second treatment fluid supply unit, and a control unit for the time staggered control of parallel process steps in the respective tanks. With such an apparatus the already above described advantages result.

Each tank preferably has a rapid discharge valve and/or an overflow. To prevent a separation or a static alteration of the treatment fluid in the treatment fluid supply unit, the latter has a fluid circuit in which the treatment fluid can be constantly kept moving. For a reprocessing of the chemicals used during the treatment, pursuant to one specific embodiment of the present invention the apparatus has a device for the return of treatment fluid from the tank to the first treatment fluid supply unit, in which a reprocessing unit is provided.

So that the apparatus takes up as little space as possible, a joint substrate handling mechanism is preferably provided for the charging and unloading of both tanks; also preferably provided are a common introduction/delivery station for preparing substrates and/or a joint unit for the concentration of the substrates for the treatment in the two

tanks. So that the substrate handling mechanism can have as simple a movement mechanism as possible, the introduction station, the device for concentrating the substrates, and/or the tanks are disposed in a row.

To prevent the substrate handling mechanism, for the charging and unloading of one tank, from having to cross over the other tank, the two tanks are preferably disposed on different sides of the unit for concentrating the substrates.

A1 Brief Description of the Drawing

The present invention will be explained in greater detail subsequently with the aid of preferred specific embodiments in conjunction with the figures. In the drawings:

Fig. 1 is a schematic plan view of an inventive treatment apparatus;

Fig. 2 is a schematic illustration of a treatment fluid flow circuit;

Fig. 3 is a schematic view of an alternative treatment fluid flow circuit;

Fig. 4 is a process sequence for the treatment of substrates in the inventive apparatus.

Description of Preferred Embodiments

Fig. 1 shows a schematic plan view upon one inventive wafer treatment apparatus 1. The apparatus 1 has a treatment station 2, an electronic switching or control cabinet 3, a heating device 4 for deionized water (DIW), a first chemical supply unit 5 for diluted hydrofluoric acid (DHF), as well as a supply unit 6 for deionized water. The electronic switching or control unit 3, the heating device 4, the chemical supply unit 5 and the supply unit 6 are all disposed outside of the actual treatment station 2. Alternatively, however, these components could also be accommodated in the treatment station 2.

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~~Provided within the treatment station 2 is an introduction/delivery storage unit 8 that serves for accommodating a plurality of wafer cassettes 10, which are introduced into or removed from the introduction/delivery storage unit by a non-illustrated charging and removal mechanism. Disposed next to the introduction/delivery storage unit 8 is a first device for concentrating the wafers, a so-called pusher 12, in which the wafers are stacked together from two wafer cassettes 10 in order, for a subsequent treatment, to form a compact set of wafers. If, for example, 26 wafers are contained in a wafer cassette 10, the stacked set in the pusher contains 52 wafers.~~

The first pusher 12 serves in a similar manner to again split the substrates after a treatment into two separate wafer cassettes 10.

Optionally, a second pusher 14 can be provided next to the first pusher 12, as shown in Fig. 1. If two separate pushers are used, one of the pushers, for example the pusher 12, can combine the substrates into a set, while the second pusher, the pusher 14, respectively splits the set.

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Furthermore disposed in the treatment station 2 is a treatment basin or tank 16, designated STT1, as well as a treatment basin or tank 18, designated STT2. To transport the wafer sets between the pushers 12 and 14 and the treatment tank 16 and 18, a transport mechanism in the form of a movable hood 20 is provided. The treatment tanks 16 and 18 are disposed in line with the pushers 12 and 14. Due to the in-line arrangement of the pushers 12,14 and the treatment tanks 16,18, it is sufficient for the hood to be movable in only two directions of movement, i.e. horizontally and vertically.

Also provided within the treatment station 2 is a chemical supply unit 22, for example for SC1, i.e. a mixture of ammonia, hydrogen peroxide and water. The chemical supply unit 22 will be explained in greater detail subsequently with reference to Fig. 2.

As can be recognized from Fig. 1, prior to charging the treatment tank 18, and after unloading the treatment tank 18, the hood 20 must in each case cross over the treatment tank 16. In so doing, the wafers disposed in the hood 20 could be influenced by the treatment processes taking place in the treatment tank 16. Therefore, the treatment tanks 16,18 could alternatively be disposed on opposite sides of the pushers 12,14, so that a crossing over of the treatment tank 16 for the charging and unloading of the treatment tank 18 is eliminated. Furthermore, it is also possible to dispose the treatment tanks 16,18 next to one another in such a way that the hood 20, on its way to one of the treatment tanks, need not cross over the other tank. In this case, however, a more complicated movement mechanism is necessary for the hood 20 since in addition to having to carry out a linear and vertical movement, the hood must also carry out a movement in a third direction.

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The construction and function of the chemical supply unit 22 will now be explained in greater detail with the aid of Fig. 2. The chemical supply unit 22 contains a heating device 24, a mixing device 26, a pump 28, filters 29,30, a concentration device 32 and a tempering

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device 34. The respective elements are interconnected by lines in the manner shown in Fig. 2 in order to form a closed circuit.

The heating device 24 and/or the mixing device 26 communicate via lines with containers for chemicals, via which containers the necessary chemicals are introduced into the circuit. It is, of course, also conceivable to introduce the chemicals into the circuit at some other location.

Lines 36,38 extend from the closed circuit to inlets 37,39 of the first and second treatment tanks 16,18. Return lines 40,42 extend from the treatment tanks 16,18 back to the circuit in the chemical supply unit 22. As can be recognized from Fig. 2, the first treatment tank 16 has a drain 44. The drain 44 has a relatively large opening that enables a rapid discharge of the treatment fluid found in the treatment tank 16.

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Furthermore, the treatment tank 16 has an overflow 46 that communicates with an outlet in order to withdraw treatment fluid that flows off over the tank.

In the same way, the treatment tank 18 has a drain 48 and an overflow 50. The return lines 40,42 can be connected with the overflows 46,50 and/or the drains 44,48.

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Within the chemical supply unit, in particular the heating device 24 and the mixing device 26 form a chemical processing unit in which the chemicals are prepared for a treatment of wafers in the treatment tanks 16,18. The capacity of the chemical supply unit, and in particular of the chemical processing unit, is designed for a single treatment tank 16,18. After the chemicals have been processed they are conveyed via the pump 28 and the filters 29,30 to the treatment tank 16,18 in which it is held for a predetermined period of time in order to carry out a treatment of the wafer contained therein. The chemicals from the treatment tanks 16,18 are subsequently conveyed back to the chemical supply unit 22. Here the chemicals are concentrated within the concentration device 32 and are conveyed further to the tempering device 34 in which they are tempered. From there the chemicals go to the feeding device 24 in which they are heated in a suitable manner to the treatment temperature.

From the heating device 24 the chemicals are conveyed to the mixing device 26, in which if necessary fresh chemicals are added and mixed

together before they are conveyed via the pump 28 and the filters 29,30 to the other tank 16,18. The processing or preparation of the chemicals within the chemical supply unit requires a certain amount of time, so that the process sequences or steps within the tanks 16,18 are controlled in a specific manner, as will be described in greater detail subsequently with the aid of Fig. 4.

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Although it was previously described in conjunction with Fig. 2 that the entire treatment fluid was returned to the chemical supply unit after a treatment in the tanks 16,18, it is also possible for the treatment fluid to be returned only partially or not at all and to be withdrawn either via the overflow 46,50 or via the drain 44,48.

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The chemical supply unit 5 for diluted hydrofluoric acid (DHF) will now be described with the aid of Fig. 3. The unit 5 contains a mixing device 52, a pump 54, filters 55,56,57, a tempering device 58, and a concentration device 60, which are connected to one another via respective lines in order to form a closed circuit. The circuit is connected via suitable lines 61,62 with the inlets 37,39 of the treatment tanks 16,18. The capacity of the chemical supply unit 5 is designed for one treatment tank 16,18 and can always supply only one tank with DHF. The mixing device 52 communicates with containers for

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chemicals, via which containers the chemicals can be introduced into the circuit. The chemicals in the circuit are in constant movement and, to the extent that they are not conveyed via the lines 61,62 to the tank 16,18, flow in the closed circuit.

The chemical supply unit 5 is designed for relatively high flow speeds, such as 50 liters per minute, and the chemicals can immediately be made available without considerable preparation time.

The staggered control, in terms of time, of the process steps in the treatment tanks 16,18 will now be explained with the aid of Fig. 4, whereby the control is effected via a non-illustrated control unit. Fig. 4 shows a time sequence of the process steps in the individual treatment tanks, with the time axis running from the top to the bottom.

The abbreviations used in the figure have the following meanings:

SC1 = treatment of the wafer with the SC1 processed in the chemical supply unit 22;

OR = Overflow Rinse, i.e. the treatment fluid found in the respective tank is displaced from the tank by introduction of a different treatment fluid and is caused to overflow

QDR = Quick Dump Rinse, i.e. the treatment fluid located in the tank is very rapidly discharged via the respective drain 44 or 48;

DHF = treatment of the wafer with diluted hydrofluoric acid;

FR = Final Rinse, i.e. the wafer is rinsed with deionized water;

MG/DRY= the substrates are moved out of the treatment fluid and are dried pursuant to the Marangoni process.

The treatment tank 18 (STT2) is first loaded or charged with wafers, while at the same time the SC1 in the chemical supply unit 22 is processed. After the charging, for a specific period of time a treatment of the wafers with SC1 is carried out in the treatment tank 18. After the treatment, the supply of SC1 into the treatment tank 18 is stopped, and at the same time new SC1 is processed in the chemical supply unit 22 for the next treatment. The SC1 still located in the treatment tank 18 is displaced out of the tank for the rinsing of the wafer by introducing Di water and is caused to overflow, or the SC1 is discharged via the rapid drain 48 and Di water is subsequently introduced into the treatment tank 18. For a certain period of time DHF is subsequently introduced into the treatment tank 18 and is held there or is continuously conveyed through. After the DHF treatment of the wafers, the DHF is displaced

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~~from the tank by introducing deionized water and is caused to overflow, and the wafers are rinsed with deionized water. The wafers are subsequently removed from the deionized water and are dried pursuant to the Marangoni process. The treatment tank 18 is now unloaded, and after a brief interval, which is necessary in order to transport the cleaned wafers away and to obtain new substrates that are to be cleaned, the tank is recharged.~~

After a staggered time period relative to the preceding, the above described process also runs in the treatment tank 16, whereby during the DHF treatment in the tank 18 the treatment tank 16 is charged with wafers. The SC1 treatment in the tank 16 is carried out during the Overflow Rinse/Final Rinse and the Marangoni drying in the tank 18. The discharge of the SC1 chemicals and the introduction of the DHF chemicals into the treatment tank 16 are effected during the unloading of the tank 18, and the DHF treatment in the tank 16 is effected during the pause between the unloading and the charging of the tank 18. The Overflow Rinse/Final Rinse in the tank 16 is effected during the charging of the tank 18. The Marangoni drying and the unloading of the tank 16 are effected during the SC1 treatment in the tank 18.

The above described time staggered control ensures that between the end of the SC1 treatment in the tank 18 and the beginning of the SC1 treatment in the tank 16 a sufficient period of time remains for the preparation or processing of the SC1 chemicals. Furthermore, the DHF treatment and the Overflow Rinse/Final Rinse treatments in the respective tanks are staggered with respect to time in such a way that they do not overlap one another. Due to this time lag between the process steps in the treatment tanks 16 and 18, it is possible, despite the necessary preparation time for the SC1, to utilize a single SC1 supply unit, the capacity of which is essentially designed for serving only a single treatment tank. The same applies to the DHF supply unit, although with this unit there does not exist a problem of a considerable preparation time for the chemicals between successive treatment stages.

Furthermore, the charging and unloading of the treatment tank 18 respectively occur between the SC1 treatment steps in the treatment tank 16. As a result, the transport of the wafers to the tank 18 and from the tank 18 are respectively effected between the SC1 treatment steps in the tank 16, so that the wafers transported over the tank 18 cannot be adversely affected by the SC1 treatment in the tank 16.

Although the present invention has been described in conjunction with a preferred specific embodiment, it is noted that the invention is not limited to the concretely illustrated embodiment. For example, a cover in the form of an essentially flat lid could be provided in order to cover at least one of the tanks when the handling device is moved over the tank. The lid can either only cover or tightly seal the tank in order to prevent contamination of the handling device or of the wafer accommodated therein. In particular, the chemicals used as well as the process steps within the treatment tanks can also deviate from what was concretely illustrated.

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